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Review

Feasibility and validity of mobile phones to assess dietary intake

Darren B. Sharp B.Med.Sc., Margaret Allman-Farinelli Ph.D., F.D.A.A. *

Department of Nutrition and Metabolism, School of Molecular Bioscience, The University of Sydney, Camperdown, Australia

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ABSTRACT

Current limitations of conventional dietary assessment methods restrict the establishment of diet–disease relationships and efficacy of dietary interventions. Technology, in particular the use of mobile phones, may help resolve methodologic limitations, in turn improving the validity of dietary assessment and research and associated findings. This review aims to evaluate the validity, feasibility, and acceptability of dietary assessment methods that have been deployed on mobile phone platforms. In August 2013, electronic databases for health sciences were searched for English, peer-reviewed, full-text articles, published from January 1, 2001 onward; and accompanied by a hand search of available relevant publications from universities and government bodies. Studies were not limited by design, length, setting, or population group. Of 194 articles, 12 met eligibility criteria: mobile phone as the dietary recording platform and validation of energy and/or macronutrient intake against another dietary or biological reference method. Four dietary recoding methods had been validated on mobile phone platforms: electronic food diary, food photograph-assisted self-administered, 24 h recall, food photograph analysis by trained dietitians, and automated food photograph analysis. All mobile phone dietary assessment methods showed similar, but not superior, validity or reliability when compared with conventional methods. Participants' satisfaction and preferences for mobile phone dietary assessment methods were higher than those for conventional methods, indicating the need for further research. Validity testing in larger and more diverse populations, over longer durations is required to evaluate the efficacy of these methods in dietary research.

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Introduction

The complex relationships between diet and disease etiology are not yet fully understood. Among the many barriers to ascertaining these answers lies the accuracy of dietary assessment methods. Methods of dietary assessment available today are fraught with inherent and extrinsic methodologic problems making accurate measures of nutritional intake extremely difficult [1]. This has the potential to lead to erroneous associations between diet and disease and inhibits the ability to assess efficacy of dietary interventions [2,3]. The development of accurate assessment methods has been part of ongoing research in the fields of dietetics and epidemiology. Recently, research has focused on harnessing technology as a viable solution to current methodologic shortcomings.

Technology has the potential to reduce researcher and participant burden, improve adherence and communication, automate and standardize coding, and upgrade data quality [4–6]. In turn, these features are likely to reduce costs associated with dietary-related research and health care. Of particular interest is the use of mobile phones in aiding dietary assessment.

Ownership of mobile phones has grown exponentially over the past 10 y with an estimated 3.2 billion active users in 2012 [7]. Mobile phones have a variety of advantageous technological features such as wireless communication, built-in cameras, global positioning systems (GPS), accelerometers, high-speed microprocessors, portable designs, and connectivity to external devices via bluetooth and infra-red, making them a convenient and suitable platform for dietary research.

These features have been implemented successfully in dietary management and intervention studies [8–11]. Less research, however, has investigated the validity of mobile phones for assessing dietary intake. Personal digital assistant (PDA) devices employing food photographs and electronic food diaries have previously proven to be a valid measure of macro- and micronutrient intake [12,13]. In the past decade, the use of PDA devices

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* Corresponding author. Tel.: +61 29 036 7045; fax: +61 29 351 5858.
E-mail address: Margaret.allmanfarinelli@sydney.edu.au (M. Allman-Farinelli).

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has been superseded by mobile phones, in particular smartphones. The aim of this review is to assess the current literature surrounding the validity, feasibility, and acceptability of the methods used to record individual's dietary intake using mobile phones, with the intent of informing future research and practice.

Methods

A structured literature search was undertaken in August 2013, with a predefined search protocol establishing inclusion and exclusion criteria. Studies using mobile phones as the dietary recording platform and published in peer-reviewed English journals from January 1, 2001 onward were included. The year 2001 was chosen to reflect the mainstream inception of the term *smartphone*. All study designs, lengths, settings, and population groups were considered. Validation of energy and/or macronutrient intake against another dietary or biological reference method was considered the primary outcome measure. For newer technologies incorporating automated image analysis, accuracy of automated processes (food segmentation, classification, volume/weight estimation, and energy calculation) were reported. Search terms were established through preliminary research and reference to the MESH database. They were divided into three hierarchical categories (ranked in order of highest to lowest importance) and searched in their complete and truncated form: DEVICE: Smart phone*, mobile phone*, mobile telephone*, mobile device*, mobile application*, cellular phone* and cell phone*; DIETARY ASSESSMENT: Food diary, food record*, food intake*, diet record*, dietary record*, dietary assessment*, dietary intake*, dietary measurement*, energy intake*, caloric intake*, nutrient intake*, nutritional intake* and nutrition* assessment*; IMAGING/SENSORS: Camera*, image*, digital image*, digital picture*, image analysis, photo*, photograph*, photography, photographing, video*, scanner* or sensor*, bar code*, segmentation*, and food volume*. Categories were searched individually and together with one or both other categories (Table 1). Database searches took place on Medline, Web of Science, CINAHL, Scopus, and Science Direct. A hand search of the document repositories of universities and government bodies for available relevant dissertations and publications was conducted using the same search terms. A manual review of main authors and selected articles, in the references of manuscripts identified in the search was also conducted.

Results

The database search yielded 20 764 publications when search strings were combined. We extracted 194 full-text articles into Endnote X6 (Thomson Reuters) for further review. Four additional articles were retrieved following a manual search of authors and screening of selected articles and bibliographies. After applying inclusion and exclusion criteria, 15 eligible studies were selected. Hand searching of universities and government bodies yielded one additional dissertation containing four studies. One study had previously been published and retrieved during the database search and another was selected after meeting eligibility criteria (Fig. 1). In all, 16 eligible studies were included and categorized as follows: self-directed dietary recording (n = 2) [14,15], food photograph analysis by trained research dietitians (n = 8) [16–22], and automated food photograph analysis (n = 6) [23–28]. Study characteristics and results are summarized in Table 2 and further described throughout the review.

Self-reported dietary recording

Electronic food diary with image capability

The validity of a smartphone electronic food diary application My Meal Mate (MMM) with imaging capability was assessed previously [15]. Participants recorded dietary intake by selecting the type and quantities of food and drink items from a food database containing 40 000 generic and branded food items. The ability to capture photographs was also incorporated to assist with dietary recall when food data was unable to be entered at the time of consumption. However, the relative use of food photographs was not reported. Validation was assessed in a sample of university staff and student volunteers. Means of 2-d MMM records showed moderate to strong correlations for energy and macronutrients when compared with the means of corresponding 24-h recalls ($r = 0.69–0.86$; $P < 0.001$). Correlations, however, were lower when 7-d MMM means were analyzed ($r = 0.64–0.75$; $P < 0.001$). Participants' incorrect portion-size estimations were reported as the method's largest source of error. Bland-Altman plots showed wide limits of agreement indicative of individual variation, but these were considerably smaller than previously reported using a PDA [13]. Notably, daily within-person variation was smaller using MMM compared with the 24-h recall. Overall, these results compare similarly with previous PDA studies using electronic food diaries [13,29]. In a related study, the MMM phone app showed superior adherence, usage, convenience, social usability, and overall satisfaction when compared with a conventional pen-and-paper food diary over a 6-mo period [30].

Food photographs used to aid in dietary recall

The use of passively captured food photographs to later aid participants' memory and portion-size estimations in a web-based self-administered 24 h recall previously was examined [14]. Images were automatically captured using a camera-enabled smartphone worn around participants' necks. Daily median energy intakes compared very well with criterion

Table 1
Database search methods and results

Search categories		ML	CHL	Scop	WOS	SD	Total
1	Device	4626	570	2159	28 166	3305	38 826
2	Dietary assessment	35 578	12 309	27 327	97 627	28 273	201,114
3	Imaging/sensors	377,545	33 975	28 115	1,351,942	229,611	2,021,188
1&2	(merged with AND)	57*	13*	8*	86*	30*	194
1&3	(merged with AND)	744	62	13	5846	1041	7706
2&3	(merged with AND)	1626	382	214	5871	4695	12 788
1&2&3	(merged with AND)	33	6	1	36	Unable to connect search strings	76

CHL, CINAHL; ML, Medline; SD, Science Direct; Scop, Scopus; WOS, Web of Science.
* Number of papers selected.

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